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(54) Internal combustion engine with fuel injection unit.

(57) The present invention relates to a fuel injection unit (1) for an internal combustion engine comprising a fuel passage (14) for supplying fuel and an air passage (16) for supplying pressurized air, into which the outlet (15) of said fuel passage (14) for supplying fuel opens and an injection valve (10) for opening and closing at least the air outlet (16a) of said air passage (16), wherein said fuel passage (14) and said air passage (16) are provided independently of each other. Moreover, fuel injection is performed either with a certain delay with respect to the initiation of the pressurized air injection or is carried out simultaneously therewith in order to ensure that the fuel becomes sufficiently atomized and that improved combustion stability is obtained.

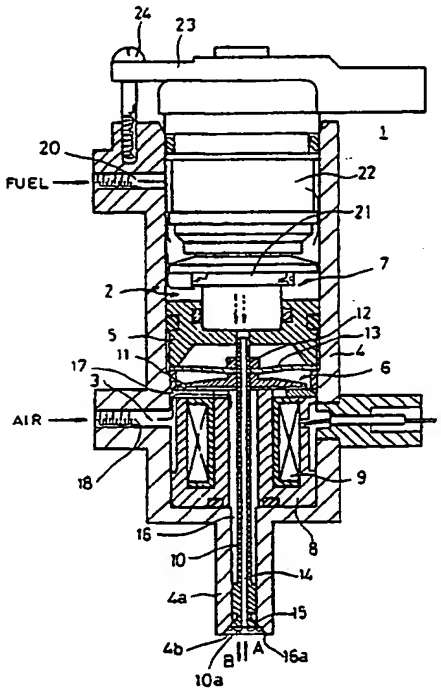

FIG.1

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INTERNAL COMBUSTION ENGINE WITH FUEL INJECTION UNIT

The present invention relates to an internal combustion engine including at least one fuel injection unit for supplying fuel into an associated combustion chamber of the internal combustion engine. Moreover, the invention relates to such a fuel injection unit per se adapted to be associated to the related cylinder head of a cylinder plug of an internal combustion engine. Finally, the invention relates to a method for injecting a fuel/air-mixture.

Among various kinds of fuel injection units for injecting fuel into the internal combustion engine combustion chamber which have so far been proposed to improve combustion stability, there is one, as disclosed by, e.g., Japanese Provisional Patent Publication S62-93481, in which fuel and air are premixed and then this fuel-air premix is injected into the engine combustion chamber.

Hereupon, if fuel and air are premixed and then injected, although fuel is supplied together with air even at the start and termination of injection, it happens there that fuel is supplied under an insufficiently atomized condition which is a cause of poor combustion stability of the internal combustion engine, because the injection flow speed becomes smaller at the start and termination of injection.

Moreover, in the prior art, when the injection valve for injecting the fuel/air-mixture is in its closed position, fuel is supplied into the chamber or air passage wherein fuel and air are premixed and, accordingly, in which the air is supplied. In that case, some fuel is apt to flow towards the upstream side of said mixture make-up chamber or air passage and adheres there even when the injection valve is being opened. As a result thereof, the exact supply of a premetered amount of fuel to the cylinder is deteriorated and, accordingly, the engine output lacks optimal performance.

Accordingly, it is one of the objectives of the present invention to provide an internal combustion engine including a fuel injection unit as indicated above enabling to ensure an exact metered amount of fuel in a sufficiently atomized condition being supplied to the combustion chamber of the engine, thus improving the engine combustion stability and performance.

Moreover, the present invention intends to provide a fuel injection unit enabling an exact predetermined amount of sufficiently atomized fuel to be injected into the combustion chamber preferably in form of a premixed fuel/air-mixture of the cylinder of an internal combustion engine.

Moreover, it is an objective of the present invention to provide an improved method for injecting a fuel/air-mixture from a fuel injection unit of an internal combustion engine into a combustion chamber of a cylinder thereof in order to reliably prevent fuel from being supplied into the air passage when the injection valve is in its closed position assuring, moreover, improved atomization of the fuel.

Finally, it is an object of the present invention to provide an improved internal combustion engine wherein sufficiently atomized fuel is injected into the combustion chamber thereof and an exact metered amount of fuel can be supplied at each injection, avoiding fuel deposition to occur in the area of the pressurized air supply passage.

In order to achieve the afore-mentioned objectives, according to the present invention, a fuel injection unit is provided which is characterised in that the fuel passage for supplying fuel and the air passage for supplying pressurized air are provided independently of each other. Moreover, a control method is provided to set the timing of fuel injection from fuel outlets of the fuel passage in such a manner that fuel injection is started only simultaneously with the injection of pressurized air being intiated or that fuel injection is started after the injection of pressurized air from the air outlet of the air passage has started wherein the fuel injection is terminated either before the injection of pressurized air is terminated or fuel injection is at least terminated simultaneously with the termination of injecting pressurized air. Generally, any advanced fuel injection prior to the initiation of the injection of pressurized air is reliably prevented.

According to the present invention, the new internal combustion engine is characterised by the provision of a fuel injection unit comprising independent fuel and pressurized air supply passages, respectively, wherein the fuel outlets open into the air supply passage facing same shortly upstream of the air outlets of the pressurized air supply passage.

Preferred embodiments of the present invention are laid down in the subclaims.

Specifically, the fuel injection unit according to the present invention is preferably designed in that the fuel outlets of the fuel passage join with the air passage near the air outlet thereof in such a manner that the fuel outlets face with the air flow passage. The timing of fuel injection from the fuel outlets of the fuel passage is variable depending the operating conditions of the engine.

The fuel injection unit, the method for injecting a fuel/air-mixture and the internal combustion engine, according to the present invention, exhibit a plurality of advantageous effects as, since the fuel passage and the air passage are made independent of each other and the pressurized air is being

introduced from the air outlet of the air passage before the fuel injection is started or terminated or at least is performed simultaneously therewith, fuel can be sufficiently atomized even at the start or the termination of fuel injection and the combustion stability can be improved.

Further, in case that the fuel outlets of the fuel passage open near the air outlet of the air passage in such a manner that the fuel outlets face with the air flow passage, the fuel is carried by the air flow to be supplied into the combustion chamber of the engine and fuel atomization is further improved and enhanced.

Still, in case that the timing of fuel injection from the fuel outlets of the fuel passage is variable according to the operating conditions of the engine, fuel can be supplied according to the engine operating conditions such as speed, load, etc. and the fuel consumption is improved while the mixture-by can be prevented.

Further objectives, features and advantages of the present invention will become more apparent from the following description of specific embodiments of the present invention in conjunction with the accompanied drawings wherein:

Figure 1 is a sectional view of a fuel injection unit according to the present invention,

Figure 2 is a sectional view of a valve member portion of the injection valve according to the present invention on a larger scale,

Figure 3 is a sectional view along the line III-III of Figure 2,

Figure 4 is a diagram showing the fuel injection timing according to one embodiment of an injection timing method according to the present invention,

Figure 5 is a time chart showing the fuel injection timing according to the diagram of Figure 4,

Figure 6 is a diagram showing another fuel injection timing according to another embodiment of an injection timing method according to the present invention,

Figure 7 is a time chart showing the fuel injection timing according to the diagram of Figure 6,

Figure 8 is a sectional view of a fuel injection unit according to another embodiment of the present invention,

Figure 9 is a sectional view of a valve member portion of the fuel injection unit according to Figure 8 on a larger scale,

Figure 10 is a sectional view along the line VIII-VIII of Figure 8,

Figure 11 is a sectional view of still another embodiment of a valve member portion of an injection valve accomodated in a fuel injection unit according to the present invention on a larger scale.

In the following, a first embodiment of the present invention is described in detail referring to the appendent drawings, Figures 1 to 7, as explained above.

In these drawings, the reference number 1 denotes a fuel injection unit to be mounted on the cylinder of an internal combustion engine (not shown) to inject fuel and air into its combustion chamber. This fuel injection unit 1 is provided with a fuel injection system 2 for injecting fuel and an air injection system 3 for injecting pressurized air independently of each other.

The housing 4 of this fuel injection unit 1 is divided by a partition 5 into an air chamber 6 and a fuel chamber 7, the air chamber 6 accomodating a holder 8 provided with an electromagnetic coil or solenoid 9 to be controlled electronically by a controller (not shown) to move the injection valve 10 in the direction B to open it when energized. An injection valve 10 is inserted through the tip portion 4a of the housing 4, holder 8 and partition 5, and on this injection valve 10 is mounted, through a stopper 11 and a nut 12, a spring 13 which spring 13 is secured on the housing 4 always urging the injection valve 10 in the direction A for closing it.

The injection valve 10 has an axial fuel passage 14 formed through its stem, and the valve portion 10a of the injection valve 10 is abutted against the valve seat 4b at the tip 4a of the housing 4 when closed. The valve portion 10a of the injection valve 10 has fuel outlets 15 formed therethrough in communication with the fuel passage 14 in such a manner that fuel is injected radially in, e.g., eight directions. The fuel outlets 15 are closed while the valve portion 10a of the injection valve 10 is in contact with the valve seat 4b of the housing 4, and are opened to enable fuel injection when the injection valve 10 is moved in the direction B and, thus, the valve portion 10a is detached from the valve seat 4b. The fuel outlets 15 of the fuel passage 14 are opened near the air outlet 16a of the air passage 16 in such a manner that the fuel outlets 14a face with the air flow passage, the fuel is carried by the air flow to be supplied into the engine combustion chamber and fuel atomization is further improved. As is shown, the valve seat 4b at the tip 4a of the housing 4 is in the shape of a downwardly expanding truncated cone with the valve member portion member 10a of the fuel injection valve 10 being shaped correspondingly to establish sealing contact in between an outer conical surface of the valve member portion 10a and the valve seat 4b of the fuel injection valve 10.

The air passage 16 is formed around the injection valve 10 between it and holder 8 and also between it and the tip 4 of the housing 4, is

communicated with the air chamber 6 through the communicating passage 17 formed in the holder 8 and is continually supplied with pressurized air through an air introducing port 18 formed through the housing 4.

As shown in Figures 2 and 3, the air passage 16 is communicated with the valve member portion 10a side of the injection valve 10 through communicating holes 19 formed through circumferentially extending guide projections of the injection valve 10. When the valve portion 10a is detached from the valve seat 4b of the housing 4, pressurized air is injected from the air outlet 16a, mixed with fuel injected from the injection valve 10 and then is injected into the combustion chamber together with fuel under atomized condition.

The injection valve 10 is a common valve for opening and closing both the fuel outlets 15 of the fuel passage 14 and the air outlet 16a of the air passage 16, and the pressurized air continually supplied from the air introducing port 18 controls the timing of injection from the air outlet 16a into the combustion chamber by opening and closing this injection valve 10. Timings of pressurized air supply from this air introducing port 18 and of opening/closing of the injection valve, may be synchronized.

Into the fuel chamber 7 is continually supplied fuel from the fuel supply port 20, which fuel is supplied, through a filter 21, to the well-known electromagnetic injector 22, which, in turn, injects the fuel from the fuel outlets 15 through the fuel passage 14 formed through the injection valve 10 at a predetermined timing. The pressure of the fuel to be injected by the injector 22 is set higher than that of the pressurized air by a definite amount.

The injector 22 is simply assembled in the housing 4 by inserting it into the housing 4 and holding it down by the cover 23 fastened by screws 24. Further, since the axis of this injector 22 is in alignment with that of the injection valve 10, this injection unit can be compact as a whole.

The injection timings of this injection unit is shown in Figures 4 and 5.

In Figure 4, "air injection started" means that the injection valve 10 is opened and air injection from the air outlet 16a is started, and "air injection terminated" means that the injection valve 10 is closed and air injection from the air outlet 16a is terminated. "Fuel injection started" and "fuel injection terminated" shows the injection timing of the injector 22.

Further, in Figure 5, "air injection" shows the timing of opening and closing of the injection valve 10, and "fuel injection" shows the injection timing of the injector 22.

That is to say, the injection valve 10 is moved in the opening direction B against the spring 13 by the energized electromagnetic coil 9 when the exhaust port provided through the engine cylinder begins to be opened, by which the pressurized air having been supplied into the air chamber 6 in the housing 4 is injected from the air outlet 16a between the valve portion 10a of the injection valve 10 and the valve seat 4b of the housing 4 through the air passage 16.

With a predetermined lag t1 after this injection of pressurized air, fuel is injected from the injector 22 and begins to be injected from the fuel outlets 15 through the fuel passage 14 of the injection valve 10. Since pressurized air is being supplied with a definite flow speed when the fuel is injected as mentioned above, the injected fuel can be appropriately atomized.

When the exhaust port is closed, with a predetermined lag of t2 after termination of fuel injection by the injector 22 and, thus, after termination of fuel injection from the injection valve 10, the electromagnetic coil 9 is deenergized, the injection valve is moved back by the spring 13 in the closing direction A, and the valve portion 10a of the injection valve 10 is brought into contact with the valve seat 4b of the housing 4 to terminate injection of pressurized air.

The fuel injection timing is such that, while the exhaust port is opened, fuel injection is started after the start of the pressurized air injection and is terminated before the termination of the pressurized air injection. In addition, since air injection is started after the exhaust port is opened and accordingly injection of fuel and pressurized air into the engine combustion chamber is started after the combustion gas has begun to be exhausted and, thus, after the pressure within the combustion chamber has begun to be lowered, the combustion gas can be prevented from flowing back into the fuel injection unit 1 while the injection pressures of fuel and pressurized air are not required to be immoderately higher.

Further, since fuel is injected at points where the pressurized air is flowing at a high speed, fuel can be satisfactorily atomized, and still further, since the pressurized air is being injected before the start and after termination of fuel injection, fuel can be atomized satisfactorily even at early and final stages of fuel injection and, thus, combustion stability can be improved.

Further, the timing of fuel injection from the fuel outlets 15 of the fuel passage 14 can be varied according to the engine operating conditions such as its speed or load. For example, the blow-by of fuel-air mixture from the exhaust port can be prevented by supplying fuel earlier within the high speed rotation range of the internal combustion engine and later within the low speed rotation range. On the other hand, while fuel is supplied

earlier within high load operating range, fuel supplying timing can be retarded to improve combustion stability within low load operating range through laminar combustion.

According to another preferred embodiment of the present invention in its method aspects, as is shown in Figures 6 and 7, fuel injection is started at the same time when the injection valve opens, i.e., simultaneously with the start of the air injection. Similarly, according to such a control method for triggering a fuel and an air supply simultaneously, the fuel injection is terminated at the same time when the injection valve is closed, i.e., simulaneously with termination of the pressurized air injection. Also in this way, fuel is not supplied to the air passage when the injection valve is in its closed position and, accordingly, the fuel will be supplied to the combustion chamber of the cylinder exactly metered and atomized.

Summarizing both timing methods for injecting fuel into the pressurized air flow, it is important that, in no way, fuel injection is triggered prior to the initiation of pressurized air injection into the combustion chamber. That is, the timing of fuel injection is controlled thus, that it starts only simultaneously with the opening of the injection valve, i.e., at the same time with pressurized air injection or starts with a certain delay with respect to said air injection, and said fuel injection is terminated prior to closing the injection valve, i.e., prior to the pressurized air injection being terminated or is at least performed simultaneously with the shut-off of pressurized air injection by closing the injection valve. Thus, combustion stability can be improved and an exactly metered fuel/air-mixture can be supplied into the combustion chamber of the engine.

Figures 8 to 10 show a second embodiment of this invention. Figure 8 being a sectional view of a fuel injection unit, Figure 9 a sectional view of its injection valve portion on a larger scale, and Figure 10 a sectional view along the line VIII-VIII of Figure 6.

The fuel injection unit 31 in this embodiment is mounted near the ignition plug 33 of the cylinder 32 of a 2-cycle internal combustion engine, and has a fuel injection system 34 for injecting fuel and an air injection system 35 for injecting pressurized air provided independently of each other. The cylinder 32 has an exhaust port 80 formed therethrough.

The housing 36 of the fuel injection unit 31 is covered by a detachable cap 81 and has an electromagnetic coil or solenoid 37 mounted therein to operate the injection valve 38 which is kept urged in the closing direction A by a spring 42 mounted under precompression between a retainer 39 secured within the housing 36 and a stopper 41 fastened by a nut 40. The urging force of this spring 42 is set through adjusting the distance between the stopper 41 and the retainer 39 by rotating an adjuster nut 43 with a tool when assembling with the cover 60 removed. After completion of this adjustment, the retainer 39 is fixed by caulking the notch portion 36a of the housing 36. By this adjustment, the opening/closing movement of the injection valve 38 can be made correct, and the contact between the valve portion 38a and the valve seat 44a can be fixed at a predetermined relationship.

Within the valve side of the housing 36 is provided a holder 44 through which is provided an injection valve 38 axially slidably. Between the holder 44 and the injection valve 38 is formed an air passage 45 into which is continually supplied pressurized air from the air supply port 46 provided through the cover 60. The injection valve 38 has a valve member portion 38a and communicating holes 38b, and the pressurized air from the air passage 45 is supplied toward the valve member portion 38a through the communicating holes 38b and, when the valve portion 38a is opened, is injected into the combustion chamber 47 from the air outlet 62 formed between the valve portion 38a and the valve seat 44a of the holder 44.

Between the holder 44 and the housing 36 is formed a fuel passage 48 into which is supplied fuel from the injector 49 fastened on the housing 36 through a fuel passage 50. At its lower end, the fuel passage 48 forms a broadened annular chamber section.

The fuel from the fuel passage 48 and its broadened chamber section at the lower end thereof, formed between the holder 44 and the housing 36 is injected in the direction of the valve portion 38a of the injection valve 38 through inclined fuel outlets 51 formed through the valve seat 44a, which outlets 51 are faced with the air flow passage opening onto the seat surface of the valve seat 44a formed at the tip of the holder 44. The fuel injection timing of this injection unit 31 is set similar to that for the first embodiment mentioned above or to the second embodiment of the method for appropriate fuel injection timing as indicated in Figures 6 and 7, respectively.

The fuel outlets 51, as shown in Figure 9, may be spaced apart circumferentially from one another to form separate fuel outlets 51 or the outlet port at the sealing surface of the valve seat 44a thereof may be communicated through an angular groove connecting the separate outlets 51 to one another.

Again, the valve member portion 38a may have a hemispherical or truncated cone-shaped configuration with the cooperating valve seat 44a adapted thereto.

Further, the injection valve 38 may either

open/close both fuel passage 45 and fuel passage 48 simultaneously as mentioned above, or as shown in Figure 11, open/close only fuel/air passage 45 by forming fuel outlets 51 in communication with the air passage 45. According to the embodiment of Figure 11, the lower end of the fuel supply passage 48 terminates into a broadened chamber section in between the housing 36 and the holder 44 and a plurality of fuel outlets 51 branch from said broadened annular chamber section through the holder 44 upstream of the valve seat 44a to open into the air supply passage 45 upstream of the valve member portion 38a of the fuel injection valve 38.

With the fuel injection unit according to this invention, since the fuel passage for supplying fuel and the air passage for supplying pressurized air are provided independently of each other, and the timing of fuel injection from the fuel outlets of the fuel passage is set in such a manner that fuel injection is started simultaneously with or after air injection from the air outlet of the air passage is started and is terminated before air injection is terminated or at least simultaneously therewith, the pressurized air is being injected from the air outlet of the air passage at a predetermined flow speed when fuel injection is started or terminated, fuel can be sufficiently atomized even at the start or the termination of fuel injection, and the combustion stability can be improved.

Further, since the fuel outlets of the fuel passage are opened near the air outlet of the air passage in such a manner that the fuel outlets face with the air flow passage, the fuel is carried by the air flow to be supplied into the engine combustion chamber and fuel atomization is further improved.

Still, the timing of fuel injection from the fuel outlets of the fuel passage can be varied according to the operating conditions of the engine, fuel can be supplied according to the engine operating conditions such as its speed, load, etc., and the fuel consumption is improved while the mixture blow-by can be prevented.

Claims

1. A fuel injection unit for an internal combustion engine, comprising a fuel passage for supplying fuel and an air passage for supplying pressurized air into which the outlet of said fuel passage for supplying fuel opens and an injection valve for opening and closing at least the air outlet of said air passage **characterised in that**, said fuel passage (14) for supplying fuel and said air passage (16) for supplying pressurized air are provided independently of each other.

2. A fuel injection unit as claimed in claim 1, **characterised in that**, that the at least one fuel outlet (15) of the fuel passage (14) joins into the air passage (16) near the air outlet (16a) of the air passage (16) in such a manner that the fuel outlet (15) faces with the air flow passage (16).

3. A fuel injection unit as claimed in claim 2, **characterised in that**, that at least one fuel outlet (15) opens into the air flow passage (16) shortly upstream of the air outlet (16a) of the air flow passage (16).

4. A fuel injection unit as claimed in claim 3, **characterised in that**, the fuel supply passage (14) terminates into a plurality of spaced fuel outlets (15), facing with the air flow passage (16a) shortly upstream of the valve controlled air outlet (16a), respectively.

5. A fuel injection unit as claimed in at least one of the preceding claims 1-4, **characterised in that**, the air flow passage (16) opens into a downwardly expanding outlet (16a) to establish a valve seat (4b) at a lower end portion of a housing (4) cooperating with a valve member portion (10a) of the elongated fuel injection valve (10).

6. A fuel injection unit as claimed in at least one of the preceding claims 1-5, **characterised in that**, the fuel supply passage (14) extends through a stem portion of the elongated fuel injection valve (10) terminating into a plurality of circumferentially spaced outlet passages (15) opening onto a sealing surface of the valve member portion (10a) cooperating with the valve seat surface (4b) of a housing (4) of the fuel injection unit (1).

7. A fuel injection unit as claimed in at least one of the preceding claims 1-6, **characterised in that**, the fuel injection unit accomodates a fuel injection system (2) for injecting fuel and an air injection system (3) for injecting pressurized air independently of each other.

8. A fuel injection unit as claimed in at least one of the preceding claims 1-7, **characterised by** a partition (5) dividing the fuel injection unit (1) into an air chamber (6) and a fuel chamber (7) wherein the air chamber (6) accomodating a holder (8) adapted to support an electromagnetic coil or solenoid (9) cooperating with the injection valve (10) received in the housing (4).

9. A fuel injection unit as claimed in claim 8, **characterised in that**, the electromagnetic coil (9) is controlled electronically by a controller to move the injection valve (10) in a downwards direction (B) to open the injection valve (10) upon energizing said coil (9).

10. A fuel injection unit as claimed in claim 9, **characterised in that**, the injection valve (10) is inserted through a tip portion (4a) of the housing (4), the holder (8) and the partition (5).

11. A fuel injection unit as claimed in claim 10, **characterised in that**, a spring (13) is connected

to the fuel injection valve (10) by means of a stopper (11) and a nut (12) wherein an outer circumferential margin of the spring (13) is secured on the housing (4), thus continuously urging the injection valve (10) in an upward direction (A) to perform sealing contact with the valve seat (4b) biasing the injection valve member portion (10a) in a closed position of the fuel injection valve (10).

12. A fuel injection unit as claimed in at least one of the preceding claims 1 to 11, **characterised in that**, the injection valve (10) is provided with an axial fuel passage (14) extending through its stem portion and the valve member portion (10a) of the injection valve (10) is abutted against the valve seat (4b) at the tip (4a) of the housing (4) when the fuel injection valve (10) is closed.

13. A fuel injection unit as claimed in at least one of the preceding claims 1 to 12, **characterised in that**, the valve member portion (10a) of the fuel injection valve (10) includes a plurality of fuel outlets (15) formed radially therethrough in communication with the axial fuel passage (14) in a manner that fuel is injected radially from the axial fuel supply passage (14) through said radial fuel outlets (15), preferably in eight directions.

14. A fuel injection unit as claimed in at least one of the preceding claims 1 to 13, **characterised in that**, the fuel outlets (15) of the fuel supply passage (14) open shortly upstream of, i.e. near an air outlet (16a) of an air passage (16) in a manner that the fuel outlets (15) face with the air flow passage (16) in a manner that the fuel is carried by the air flow to be supplied into the engine combustion chamber.

15. A fuel injection unit as claimed in at least one of the preceding claims 1 to 14, **characterised in that**, the valve seat (4b) at the tip (4a) of the housing (4) is in the shape of a downwardly expanding truncated cone with the valve member portion member (10a) of the fuel injection valve (10) being shaped correspondingly to establish sealing contact in between an outer conical surface of the valve member portion (10a) and the valve seat (4b) of the fuel injection valve (10).

16. A fuel injection unit as claims in at least one of the preceding claims 1 to 15, **characterised in that**, an air supply passage (16) is formed around the injection valve (10) along its stem portion in between the injection valve (10) and the surrounding holder (8) as well as in between the valve stem portion and the tip (4a) of the housing (4), said air supply passage (16) is communicated with the air chamber (6) through a communication passage (17) formed in the holder (8), said air supply passage (16) being continuously supplied with pressurized air through an air introducing port (18) formed through the housing (4).

17. A fuel injection unit as claimed in claim 16, **characterised by** guide projections integrally provided at the circumference of the stem portion of the fuel injection valve (10) at an intermediate position thereof,adapted to guide the fuel injection valve (10) axially within the accomodating air supply passage (16), said projections being recessed by axial communicating bores (19) extending axially through the integral guide projections of the stem portion of the fuel injection valve (10) to communicate the air passage (16) upstream of said guide projections with the valve member portion side (10a) of the fuel injection valve (10) downstream of said guide projections.

18. A fuel injection unit as claimed in at least one of the preceding claims 1 to 17, **characterised in that**, the injection valve (10) is a common valve for opening and closing both the fuel outlets (15) of the fuel supply passage (14) and the air outlet (16a) of the air passage (16).

19. A fuel injection unit as claimed in at least one of the preceding claims 1 to 18, **characterised by** an injector (22) accomodated in the housing (4) and adapted to inject the fuel which has been supplied continuously from the fuel supply part (20) of the housing (4) into the fuel chamber (7) through a filter (21) from the fuel outlets (15) via the fuel passage (14) extending through the injection valve (10) at a predetermined timing.

20. A fuel injection unit as claimed in claim 19, **characterised in that**, the injector (22) is inserted into the housing (4) and is held down by a cover (23) in a manner that the axis of the injector (22) is in alignment with the center axis of the injection valve (10).

21. A fuel injection unit as claimed in claim 1, **characterised by** a fuel injection system (34) for injecting fuel and air injection system (35) for injecting pressurized air being provided independently of each other and the fuel injection unit (31) being located near an ignition plug (33) of a cylinder (32) of a two-cycle internal combustion engine.

22. A fuel injection unit as claimed in claim 21, **characterised by** a housing (36) bearing an electro magnetic coil or solenoid (37) to operate an injection valve (38) which is prebiased in its closed position by a spring (42) mounted under precompression between a retainer (39), secured with the housing (36) and a stopper (41) fastened by a nut (40), with the housing being kept covered by a detachable cap (81).

23. A fuel injection unit as claimed in at least one of the preceding claims 21 and 22, **characterised in that**, the biasing force of the spring (42) is adjustable through an adjuster nut (43) enabling to correctly adjust the opening/closing movement of the injection valve (38) and the finally-adjusted assembly can be fixed in order to establish the

contact between a valve member portion (38a) of the injection valve (38) and a valve seat (44a) at the housing (4) to become fixed at a predetermined relationship.

24. A fuel injection unit as claimed in at least one of the preceding claims 21 to 23, **characterised in that**, the valve side of the housing (36) accomodates a holder (44) which, in turn, axially slidably receives an elongated stem portion of the injection valve (38) terminating into a lower valve member portion (38a) adapted to establish contact with a valve seat (44a) of the holder (44).

25. A fuel injection unit as claimed in at least one of the preceding claims 21 to 24, **characterised in that**, an air supply passage (45) is formed in between the holder (44) and the injection valve (38) continuously supplied with pressurized air from an air supply port (46) extending through the cover (60).

26. A fuel injection unit as claimed in at least one of the preceding claims 21 to 25, **characterised in that**, the injection valve (38) has a valve member portion (38a) provided at the lower end portion of the stem of the injection valve (10), said valve member portion (38a) cooperates with a corresponding contact surface of the valve seat (44a) of the holder (44) and, moreover, the injection valve (38) provides communicating holes (38b) extending through guide section of the injection valve stem portion to communicate the air supply passage (45) upstream of said guide sections with the valve portion side of the air supply passage (45) downstream of said guide sections to supply pressurized air from the air passage (45) toward the valve member portion (38a) of the injection valve (38) through the communicating holes (38b).

27. A fuel injection unit as claimed in at least one of the preceding claims 21 to 26, **characterised in that**, a fuel passage (48) is formed in between the holder (44) and the surrounding housing (36) into which fuel is supplied from an injector (49), fastened on the housing (36) through a fuel passage (50).

28. A fuel injection unit as claimed in at least one of the preceding claims 21 to 27, **characterised in that**, the lower end of the fuel supply passage (48) terminates into a broadened chamber section in between the housing (36) and the holder (44) and a plurality of inclined fuel outlets (51) branch from said broadened chamber section of the fuel supply passage (48) through the valve seat portion (44a) of the holder (44) in a manner that the outlets (51) face with the air flow passage formed in between the valve member portion (38a) of the injection valve (38) and the associated valve seat (44a) of the holder (44).

29. A fuel injection unit as claimed in claim 28, **characterised in that**, the fuel outlets (51) terminate into an angular groove recessed in the valve seat surface of the valve seat (44a) of the holder (44).

30. A fuel injection unit as claimed in at least one of the preceding claims 21 to 29, **characterised in that**, the fuel outlets (51) of the fuel supply passage (48) open into the seat surface of the valve seat (44a) of the fuel injection valve provided at the lower tip end of the holder (44).

31. A fuel injection unit as claimed in at least one of the preceding claims 21 to 27, **characterised in that**, the lower end of the fuel supply passage (48) terminates into a broadened chamber section in between the housing (36) and the holder (44) and a plurality of fuel outlets (51) branch from said broadened annular chamber section through the holder (44) upstream of the valve seat (44a) to open into the air supply passage (45) upstream of the valve member portion (38a) of the fuel injection valve (38).

32. A method for injecting a fuel/air-mixture from a fuel injection unit of an internal combustion engine into a combustion chamber of a cylinder thereof, **characterised in that**, the fuel injection unit provides for the fuel supply passage (14,48) independently of the air supply passage (16,45) and the timing of fuel injection from the fuel outlets (15,51) of said fuel passage (14,48) is set such that fuel injection is started after air injection from said air outlet (16a) of said air supply passage (16) is started, i.e. after the injection valve (10,38) begins to open, and said fuel injection is terminated before air injection is terminated, i.e., before the injection valve (10,38) is closed.

33. A method for injecting a fuel/air-mixture from a fuel injection unit of an internal combustion engine into a combustion chamber of a cylinder thereof, **characterised in that**, the fuel injection unit provides for the fuel supply passage (14,48) independently of the air supply passage (16,45) and the timing of fuel injection from the fuel outlets (15,51) of said fuel passage (14,48) is set such that fuel injection is started at the same time when air injection from said air outlet (16a) of said air supply passage (16) is started, i.e. simultaneously with the injection valve (10,38) being opened, and said fuel injection is terminated at the same time when air injection is terminated, i.e., simultaneously with the injection valve (10,38) being closed.

34. A method as claimed in claim 32 or 33, **characterised in that**, said timing of fuel injection from the fuel outlets (15,51) of the fuel passage (14,48) is variable according the operating conditions of the engine.

35. Internal combustion engine comprising a fuel injection unit having a fuel passage for supplying fuel, an air passage for supplying pressurized air into which the outlet of said fuel passage

opens and an injection valve for opening and closing at least the air outlet of said air passage, **characterised in that**, the fuel passage (14,48) for supplying fuel and said air passage (16,45) for supplying pressurized air are provided independently of each other.

36. An internal combustion engine as claimed in claim 35, **characterised by** a fuel injection unit (1,31) according to any of the preceding claims 1 to 31.

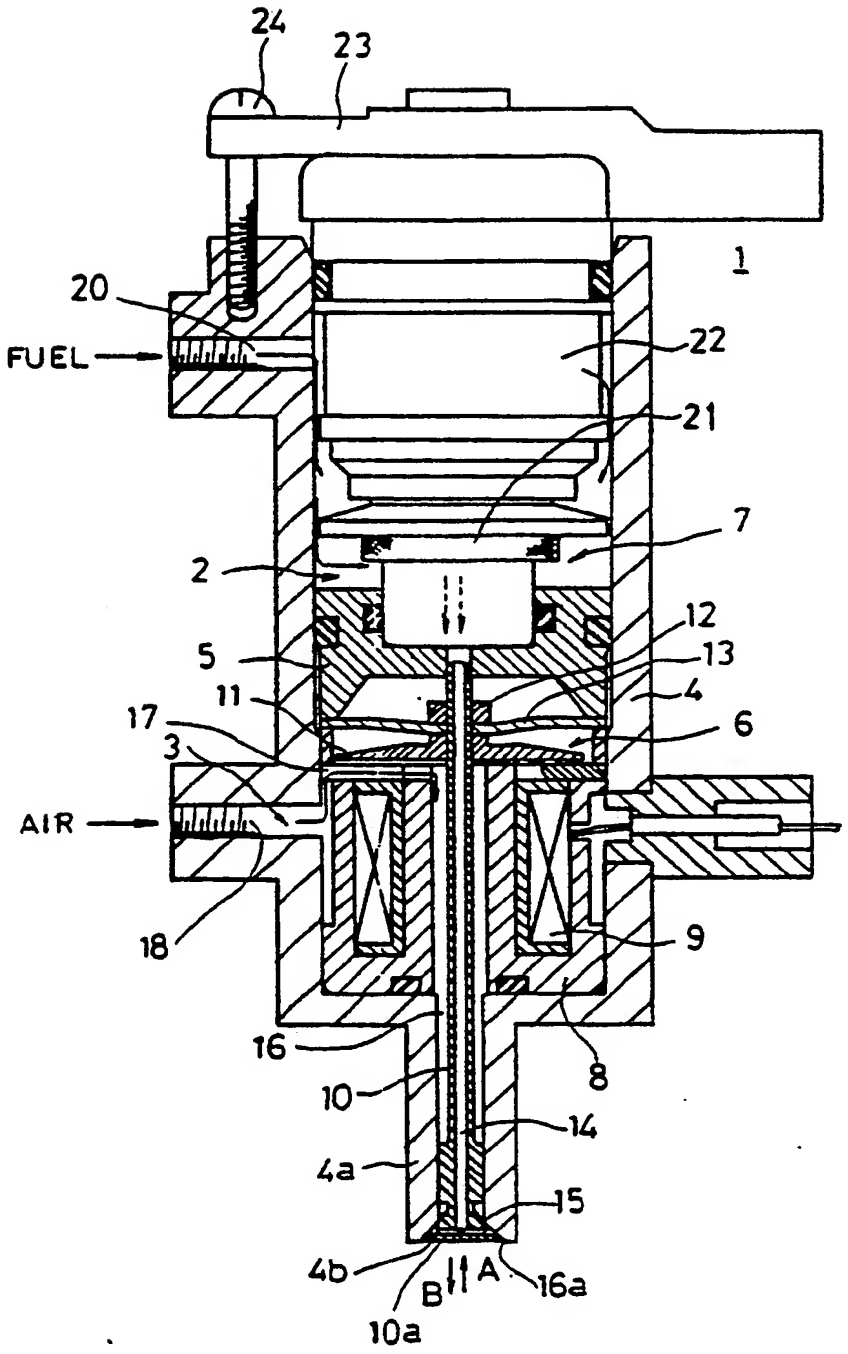

FIG.1

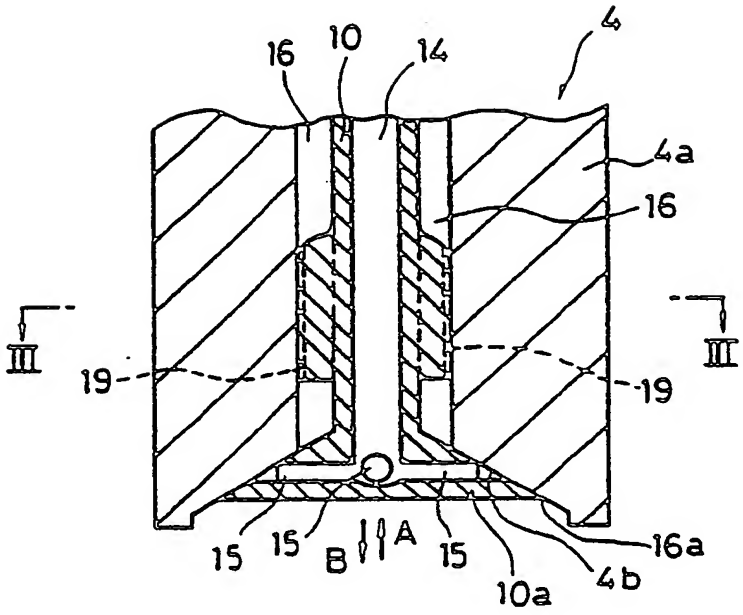
4
16
10
14
4a
16
III
III
19
19
15
15
B
A
15
16a
4b
10a

FIG.2

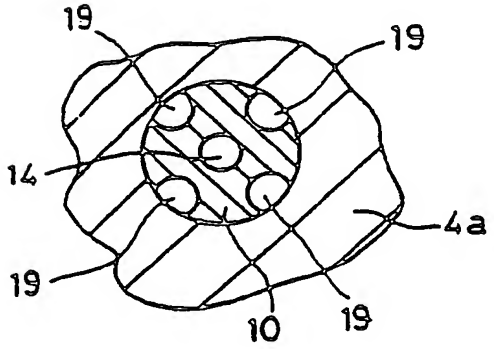
19
19
14
4a
19
10
19

FIG.3

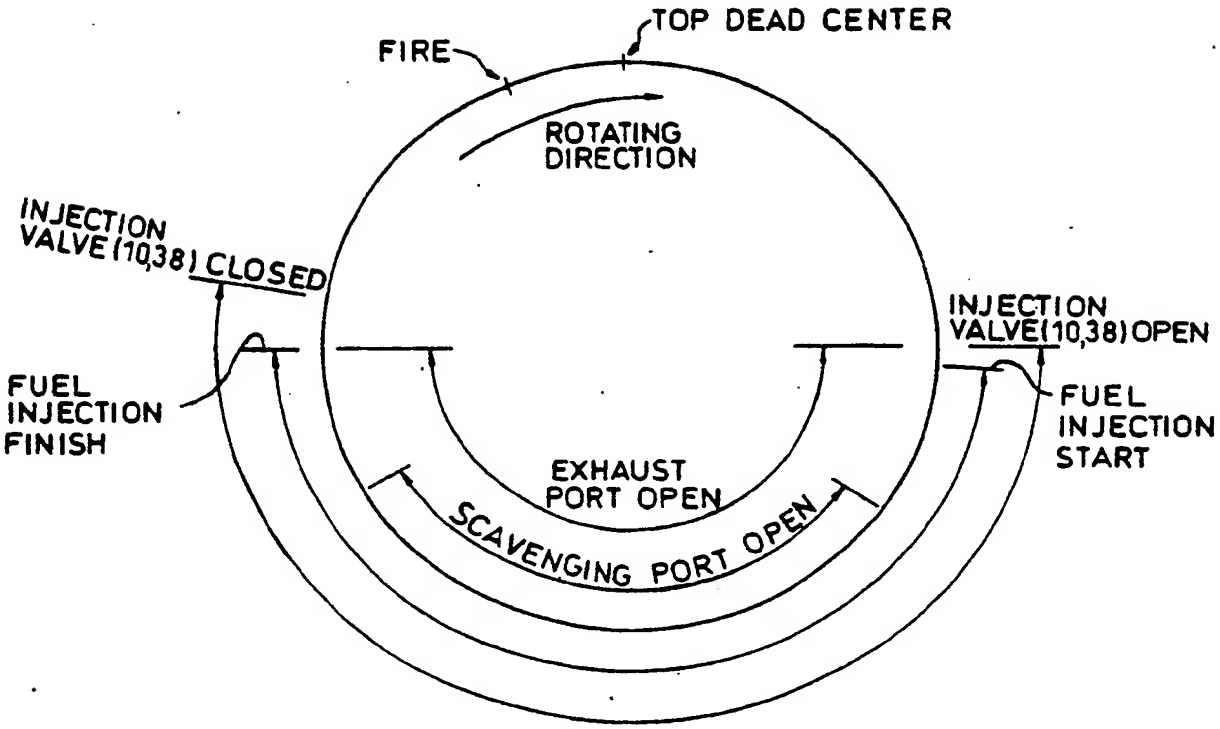

FIG.4

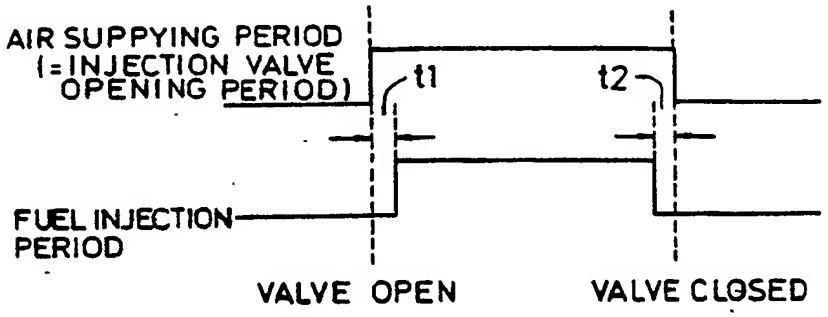

FIG.5

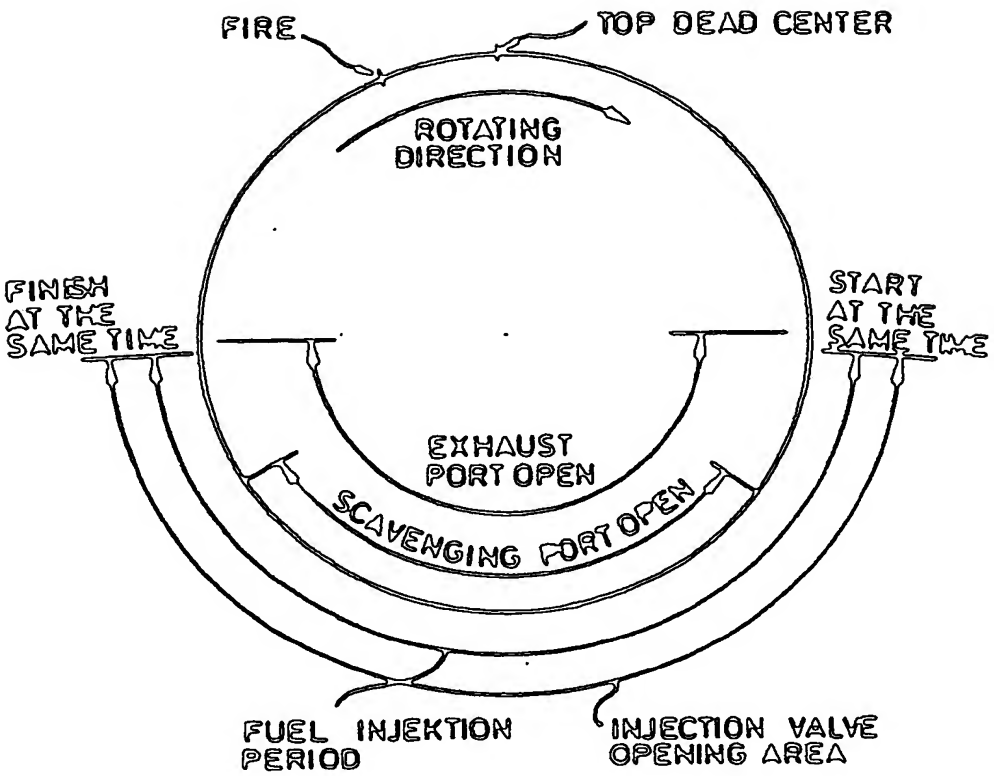

FIG.6

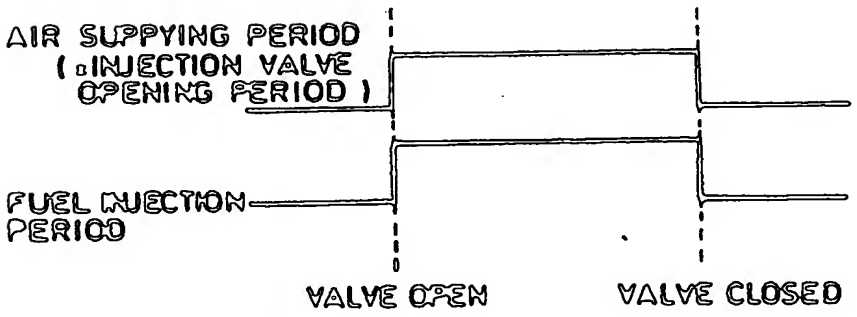

FIG.7

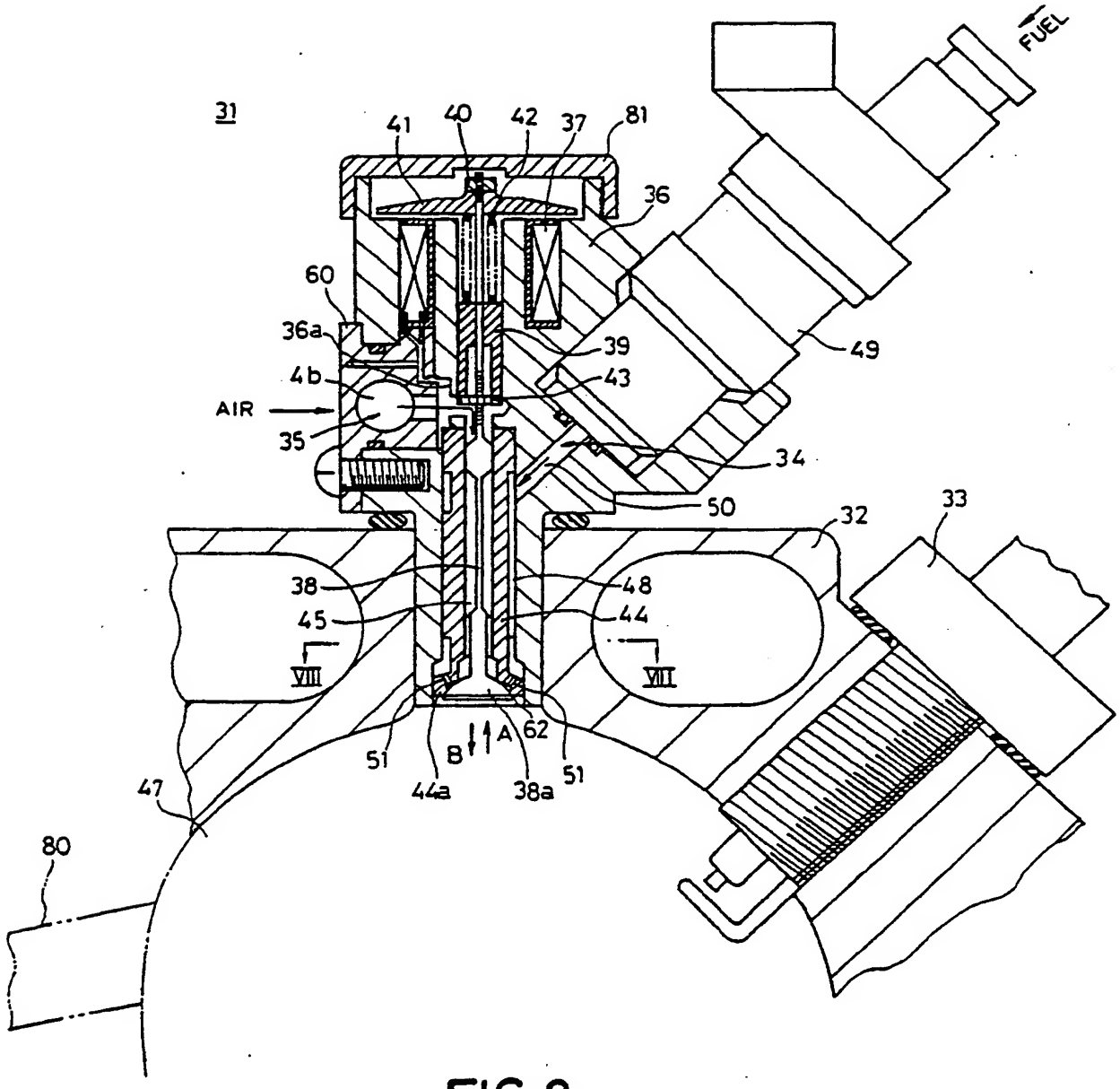

FIG.8

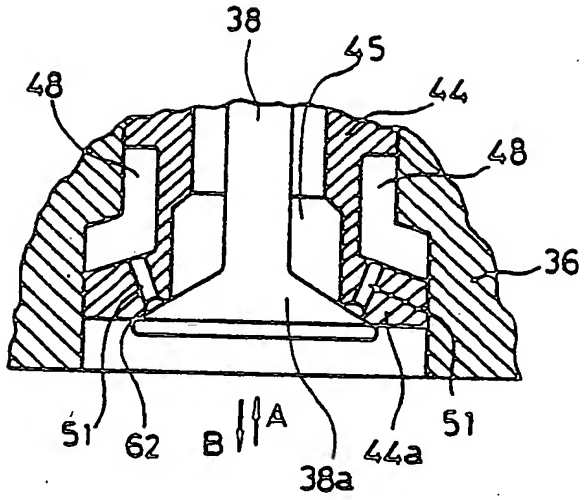

FIG.9

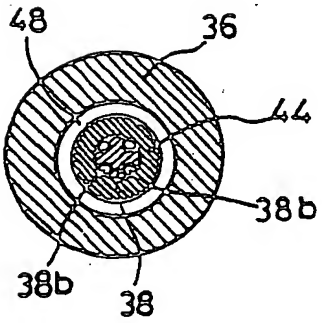

FIG.10

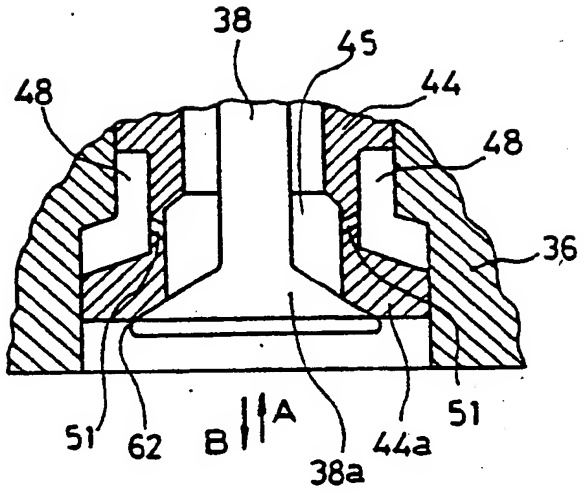

FIG.11

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 90103475.1

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl*)
X	DE - C - 841 080 (DAIMLER-BENZ AG) * Totality *	1-7	F 02 M 67/02 F 02 M 67/12 F 02 M 69/08 F 02 M 51/08 F 02 B 13/00
A	--	12-16, 18,24	
X	WO - A1 - 87/02 419 (ORBITAL ENGINE COMPANY) * Totality; especially page 11, lines 17-33 *	1-5, 33,35	
A	--	7-11, 14-16, 18,22, 28-30	
X	WO - A1 - 87/00 584 (ORBTIAL ENGINE COMPANY) * Totality; especially fig. 1,2 *	1,21, 35	
A	--	19,22	TECHNICAL FIELDS SEARCHED (Int Cl*)
X	AT - B - 82 344 (STILL) * Totality; especially page 1, lines 31-44; claim *	1,32	F 02 M 67/00 F 02 M 69/00 F 02 M 51/00 F 02 B 13/00
X	--	1	
A	US - A - 4 771 754 (REINKE) * Totality *	19,21	
X	--	1	
A	DE - A1 - 3 734 737 (ORBITAL ENGINE CO PTY LTD) * Totality *	8,9	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	08-06-1990	PIPPAN

EPO Form 1503, 03.82

CATEGORY OF CITED DOCUMENTS

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L : document cited for other reasons

& : member of the same patent family, corresponding document